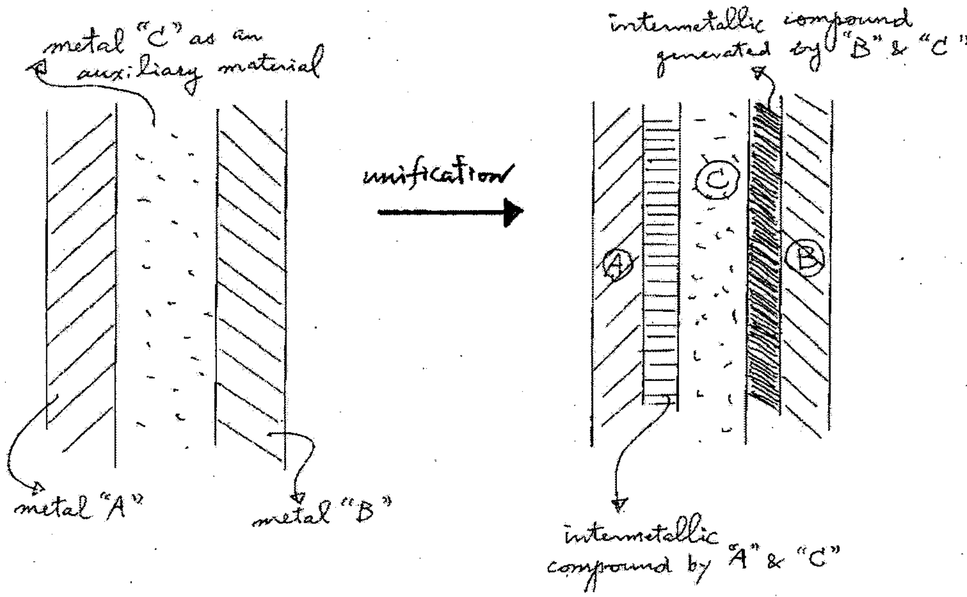
REMARKS

Claims 9-12, 14-17 and 19-28 are currently pending. Applicants reserve the right to pursue the original and other claims in this and in other applications. Applicants respectfully request reconsideration in light of the following remarks.

Claims 9-12, 14-17 and 19-28 stand rejected under 35 U.S.C. § 112, first paragraph, as failing to comply with the written description requirement. Claims 9-12, 14-17 and 19-28 stand rejected under 35 U.S.C. § 112, second paragraph, as being indefinite. These rejections are respectfully traversed and reconsideration is respectfully requested.

Applicants respectfully submit that the claim term "electrically and mechanically unified and integrated metallurgically" is clearly supported in the Specification as filed and that one of skill in the art would understand the meaning of this term. It is described in the Specification that "a junction auxiliary material 4 is arranged so as to electrically and mechanically unify or integrate the different materials into a unitary block." See, Specification, pg. 22, lines 23-26. Furthermore, the junction auxiliary material is also described in the Specification as a "brazing material." See, Specification, pg. 14, lines 8-16. As evidenced from the attached pages from Callister, Jr., William D. Materials Science and Engineering - An Introduction. 5th Ed. John Wiley & Sons, Inc: New York. 2000., one of skill in the art at the time of the invention would have known that using a "brazing material" for brazing (welding) results in a joining bond between materials that is a "metallurgical bond (involving some diffusion) rather than just mechanical." For example, if a junction auxiliary material (brazing material) "C" is provided between each of a pair of metals "A" and "B" (shown as "A"-"C"-"B"), a boundary face part results after the unification/integration of the metals (shown as "A" -"intermetallic compound of A and C" - "C" - "intermetallic compound of C and B" - "B"). A schematic illustration of this is included below (next page) for convenience.



In general, a junction auxiliary material has a lower fusing point temperature than that of a base material and the junction auxiliary material has a component that is diffused into the base metal for forming an intermetallic compound, composite metal or the like, as shown schematically in the above drawings. Examples of appropriate junction auxiliary materials are shown, for example, at pg. 37, line 23 – pg. 38, line 11 of the Specification.

Therefore, Applicants respectfully submit that the application clearly supports the claim term "electrically and mechanically unified and integrated metallurgically" and that, as discussed above, the meaning of this term would be apparent to one of skill in the art. Accordingly, Applicants submit that the claims are in compliance with 35 U.S.C. § 112. Applicants request the rejections be withdrawn and the claims allowed.

Claims 9, 10, 12, 14, 15, 17 and 19-22 stand rejected under 35 U.S.C. §102(b) as being anticipated by Thieme et al. (U.S. Appl. Pub. 2003/0036482) ("Thieme"), or in the alternative, under 35 U.S.C. §103(a) as being obvious over Thieme. Claims 9, 10, 12, 14, 15, 17 and 19-26 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Thieme in view of Wong (U.S. Patent No. 5,470,821) ("Wong") and Dunand (U.S. Patent No. 6,995,119) ("Dunand"). These rejections are respectfully traversed and reconsideration is respectfully requested.

As previously discussed, it is an important feature of the claims that an intermediate layer that operates as a junction auxiliary material is located between the metal base member and the cladding layer. The intermediate layer is electrically and mechanically unified and integrated metallurgically with the metal base member and the cladding layer in a unitary block.

As shown in the first and sixth examples of the Specification, a brass foil (i.e., a composite metal of Cu and Zn having a low fusing point) may be used as a junction auxiliary material in a superconducting wire with copper and SUS316. However, as shown in the comparative material of the examples, where the brass foil/junction auxiliary material is omitted, and thus the pair of metals (copper and SUS316) are attached only by contact or adhesion (without generation of the intermetallic compound via the junction auxiliary material), a wire arranged in such manner has low workability, which is undesired. See, Specification, pg. 24, line 3 – pg. 25, line 3.

Applicants respectfully submit that Thieme fails to disclose, or render obvious, the "junction auxiliary material" as claimed. The Examiner relies on the "metal matrix" of Thieme as disclosing this claim feature. Office Action, pg. 6. However, Applicants respectfully submit that the "metal matrix" of Thieme merely refers to a general material (e.g., copper metal or compound) provided between the Mg-B regions and the copper regions, but does not disclose a "junction auxiliary material" as claimed. As would be recognized by one of skill in the art, the claimed "junction auxiliary material," on the other hand, is a particular type of material that operates to unify different materials through diffusion bonding, as discussed above. Thieme simply does not disclose this feature, as the "metal matrix" of Thieme does not provide this important function, nor are appropriate materials disclosed. Accordingly, Applicants submit that the claims are allowable over Thieme.

In the alternative, the Examiner relies on the combination of Thieme, Wong and Dunand as rendering the claims obvious. Applicants respectfully disagree.

The Office Action relies on Wong as disclosing a metallic matrix including tin. Office Action, pg. 10. The Office Action relies on Dunand as disclosing the use of tin with magnesium boride. Id. These two references allegedly disclose the claimed tin alloy junction auxiliary material of several dependent claims. Id. However, Applicants note that Wong relates to the production of composite superconducting oxide/elemental metal materials by combining powdered materials. Wong, Abstract; col. 5, lines 25-30. Dunand also relates to the formation of superconducting metal composites. Dunand, Abstract. In Dunand, the metal used in the device is also provided in a powdered state. See, Dunand, Claim 1. The metallic components of Wong and Dunand (i.e., Wong's "matrix of elemental metal" and Dunand's "metallic component"), upon which the Examiner relies as disclosing the claimed tin junction auxiliary material, are arranged to be *added to* superconducting materials in order to improve the functional properties thereof; the metallic components of Wong and Dunand do not (and cannot) operate as the claimed "junction auxiliary material" that operates to unify different materials through diffusion bonding, as described in more detail above.

Accordingly, Applicants respectfully submit that the claims are allowable over Thieme and over the cited combination. Applicants respectfully request the rejections be withdrawn and the claims allowed.

Claims 11 and 16 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Thieme in view of Nakahara et al. (U.S. Patent No. 6,337,307) ("Nakahara"). Claims 11 and 16 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Thieme in view Wong and Dunand and of Nakahara. These rejections are respectfully traversed and reconsideration is respectfully requested.

Claims 11 and 16 depend from claims 21 and 22, respectively, which are allowable over Thieme and the Thieme/Wong/Dunand combination for at least the reasons discussed above. Nakahara is relied on as disclosing "a superconductor … where a plurality of single-core wires are assembled into a base metal and are twisted" (Office Action, pg. 9), but does not remedy the deficiencies of Thieme, Wong and Dunand, discussed above. Accordingly, Applicants respectfully

submit that claims 21 and 22, along with claims 11 and 16, are allowable over the cited Nakahara combinations. Applicants respectfully request the rejections be withdrawn and the claims allowed.

Claims 27 and 28 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Thieme in view of Wong and Dunand and further in view of Tosmic (U.S. Appl. Pub. 2002/0198111) ("Tosmic"). This rejection is respectfully traversed and reconsideration is respectfully requested.

Claim 27 includes limitations similar to those discussed above that are not disclosed by the Thieme/Wong/Dunand combination (e.g., at least the "junction auxiliary material" intermediate layer). Tosmic is relied on as disclosing "a magnesium boride wire ... wherein the magnesium boride core is surrounded, and abutted, by a layer of copper because the reactivity of copper with the magnesium boride is favorable" (Office Action, pg. 13), but does not remedy the deficiencies of Thieme, Wong and Dunand, discussed above. Accordingly, Applicants respectfully submit that claim 27 is allowable over the cited combination. Claim 28 depends from claim 27 and is allowable along with claim 27. Applicants respectfully request the rejection be withdrawn and the claims allowed.

In view of the above, Applicants believe the pending application is in condition for allowance

Dated: March 8, 2011

Respectfully submitted,

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MATERIALS SCIENCE AND ENGINEERING AN INTRODUCTION

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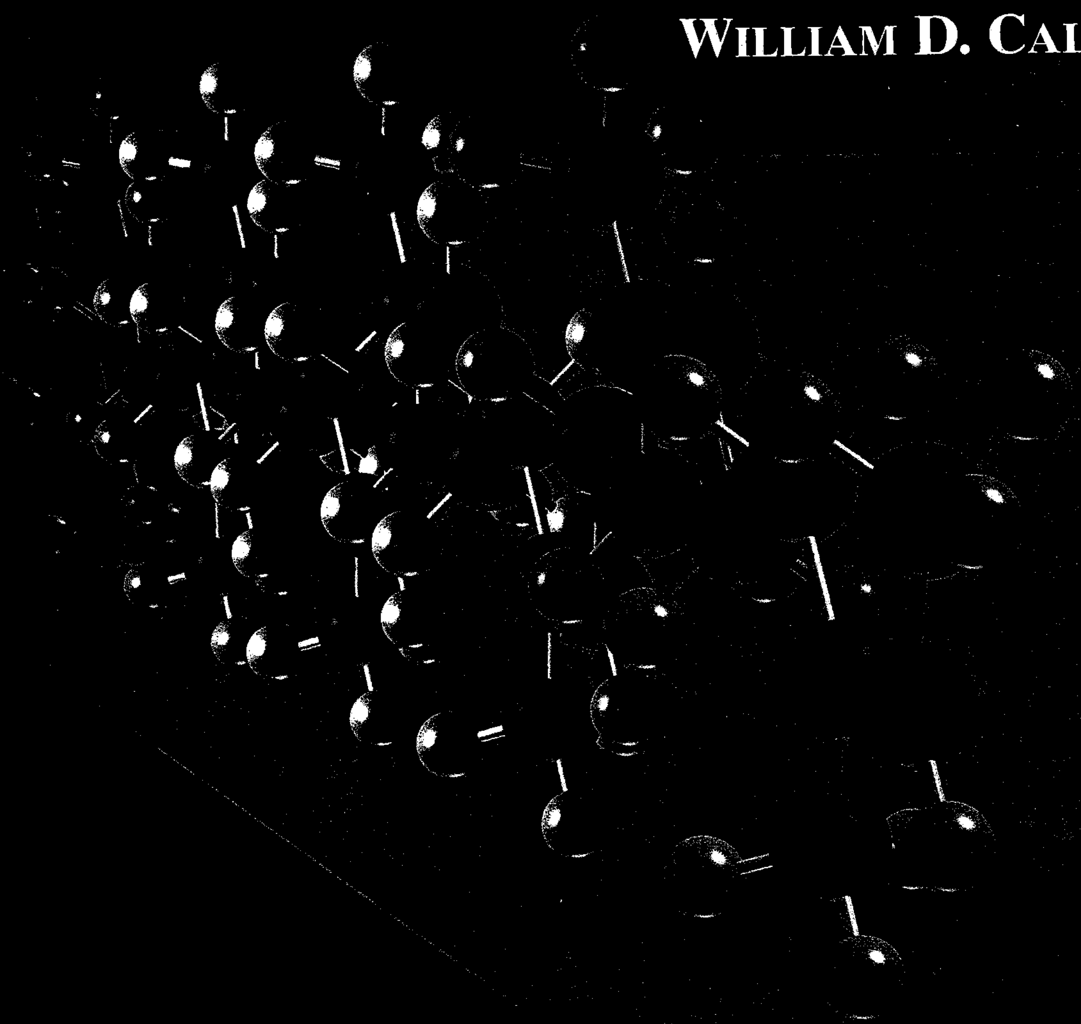

FIFTH EDITION

Materials Science and Engineering

An Introduction

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Back Cover: Depiction of a molecular segment of *trans* polyisoprene (or gutta percha). Again, the red and yellow spheres represent carbon and hydrogen atoms.

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Chapter 12 / Metal Alloys

This photograph shows the aluminum beverage can in various stages of production. The can is formed from a single sheet of an aluminum alloy. Production operations include drawing, dome forming, trimming, cleaning, decorating, and neck and flange forming. (PEPSI is a registered trademark of PepsiCo, Inc. Used by permission.)

Why Study *Metal Alloys*?

Engineers are often involved in materials selection which necessitates that they have some familiarity with the general characteristics of a wide variety of metals and their alloys (as well as other materials). In addition, access to data bases containing property values for a large number of materials may be required. For example, in Section 23.2 we discuss a materials selection process that is applied to a cylindrical shaft that is stressed in torsion.

12.4 MISCELLANEOUS TECHNIQUES

POWDER METALLURGY

Yet another fabrication technique involves the compaction of powde… followed by a heat treatment to produce a more dense piece. The process is… ately called **powder metallurgy,** frequently designated as P/M. Powder m… makes it possible to produce a virtually nonporous piece having properti… equivalent to the fully dense parent material. Diffusional processes d… heat treatment are central to the development of these properties. This me… especially suitable for metals having low ductilities, since only small plastic d… tion of the powder particles need occur. Metals having high melting temp… are difficult to melt and cast, and fabrication is expedited using P/M. Furthe… parts that require very close dimensional tolerances (e.g., bushings and gears)… be economically produced using this technique. The decorative pattern on the… blade shown in Color Plate C is produced using a powder metallurgical tech…

WELDING

In a sense, welding may be considered to be a fabrication technique. In welding… two or more metal parts are joined to form a single piece when one-part fabrica… is expensive or inconvenient. Both similar and dissimilar metals may be wel… The joining bond is metallurgical (involving some diffusion) rather than just mech… ical, as with riveting and bolting. A variety of welding methods exist, including a… and gas welding, as well as brazing and soldering.

During arc and gas welding, the workpieces to be joined and the filler mate… (i.e., welding rod) are heated to a sufficiently high temperature to cause both… melt; upon solidification, the filler material forms a fusion joint between the wo… pieces. Thus, there is a region adjacent to the weld that may have experienc… microstructural and property alterations; this region is termed the *heat-affec… zone* (sometimes abbreviated *HAZ*). Possible alterations include the following:

1. If the workpiece material was previously cold worked, this heat-affected zone may have experienced recrystallization and grain growth, and thus a diminishment of strength, hardness, and toughness. The HAZ for this situation is represented schematically in Figure 12.3.
2. Upon cooling, residual stresses may form in this region that weaken the joint.

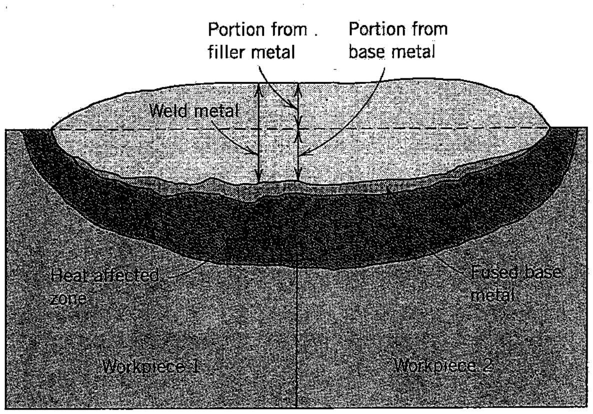

FIGURE 12.3 Schematic cross-sectional representation showing the zones in the vicinity of a typical fusion weld. (From *Iron Castings Handbook,* C. F. Walton and T. J. Opar, Editors, 1981.)

3. For steels, the material in this zone may have been heated to temperatures sufficiently high so as to form austenite. Upon cooling to room temperature, the microstructural products that form depend on cooling rate and alloy composition. For plain carbon steels that have low hardenabilities, normally pearlite and a proeutectoid phase will be present. However, for alloy steels, one microstructural product may be martensite, which is ordinarily undesirable because it is so brittle.
4. Some stainless steels may be "sensitized" during welding, which renders them susceptible to intergranular corrosion, as explained in Section 18.7.

A relatively modern joining technique is that of laser beam welding, wherein a highly focused and intense laser beam is used as the heat source. The laser beam melts the parent metal, and, upon solidification, a fusion joint is produced; often a filler material need not be used. Some of the advantages of this technique are as follows: (1) it is a noncontact process, which eliminates mechanical distortion of the workpieces; (2) it can be rapid and highly automated; (3) energy input to the workpiece is low, and therefore, the heat-affected zone size is minimal; (4) welds may be small in size and very precise; (5) a large variety of metals and alloys may be joined using this technique; and (6) porosity-free welds with strengths equal to or in excess of the base metal are possible. Laser beam welding is used extensively in the automotive and electronic industries where high quality and rapid welding rates are required.

In addition to laser beams, electron beams may also be used as heat sources for welding metals; Color Plate K shows the microstructure within the vicinity of an electron beam weld junction.

FERROUS ALLOYS

Ferrous alloys—those of which iron is the prime constituent—are produced in larger quantities than any other metal type. They are especially important as engineering construction materials. Their widespread use is accounted for by three factors: (1) iron-containing compounds exist in abundant quantities within the earth's crust; (2) metallic iron and steel alloys may be produced using relatively economical extraction, refining, alloying, and fabrication techniques; and (3) ferrous alloys are extremely versatile, in that they may be tailored to have a wide range of mechanical and physical properties. The principal disadvantage of many ferrous alloys is their susceptibility to corrosion. This chapter discusses compositions, microstructures, and properties of a number of different classes of steels and cast irons. A taxonomic classification scheme for the various ferrous alloys is presented in Figure 12.4.

12.5 STEELS

Steels are iron–carbon alloys that may contain appreciable concentrations of other alloying elements; there are thousands of alloys that have different compositions and/or heat treatments. The mechanical properties are sensitive to the content of carbon, which is normally less than 1.0 wt%. Some of the more common steels are classified according to carbon concentration, namely, into low-, medium-, and high-carbon types. Subclasses also exist within each group according to the concentration of other alloying elements. **Plain carbon steels** contain only residual concentrations of impurities other than carbon and a little manganese. For **alloy steels**, more alloying elements are intentionally added in specific concentrations.

total number of moles (or atoms) of all elements within an alloy.

Austenite. Face-centered cubic iron; also iron and steel alloys that have the FCC crystal structure.

Austenitizing. Forming austenite by heating a ferrous alloy above its upper critical temperature—to within the austenite phase region from the phase diagram.

B

Bainite. An austenitic transformation product found in some steels and cast irons. It forms at temperatures between those at which pearlite and martensite transformations occur. The microstructure consists of α-ferrite and a fine dispersion of cementite.

Band gap energy (E_g). For semiconductors and insulators, the energies that lie between the valence and conduction bands; for intrinsic materials, electrons are forbidden to have energies within this range.

Bifunctional. Designating monomer units that have two active bonding positions.

Block copolymer. A linear copolymer in which identical mer units are clustered in blocks along the molecular chain.

Body-centered cubic (BCC). A common crystal structure found in some elemental metals. Within the cubic unit cell, atoms are located at corner and cell center positions.

Bohr atomic model. An early atomic model, in which electrons are assumed to revolve around the nucleus in discrete orbitals.

Bohr magneton (μ_B). The most fundamental magnetic moment, of magnitude 9.27×10^{-24} A-m^2.

Boltzmann's constant (k). A thermal energy constant having the value of 1.38×10^{-23} J/atom-K (8.62×10^{-5} eV/atom-K). See also **Gas constant.**

Bonding energy. The energy required to separate two atoms that are chemically bonded to each other. It may be expressed on a per-atom basis, or per mole of atoms.

Bragg's law. A relationship (Equation 3.9) which stipulates the condition for diffraction by a set of crytallographic planes.

Branched polymer. A polymer having a molecular structure of secondary chains that extend from the primary main chains.

Brass. A copper-rich copper–zinc alloy.

$\boxed{\text{**Brazing.** A metal joining technique that uses a molten filler metal alloy having a melting temperature greater than about 425°C (800°F).}}$

Brittle fracture. Fracture that occurs by rapid crack propagation and without appreciable macroscopic deformation.

Bronze. A copper-rich copper–tin alloy; aluminum, silicon, and nickel bronzes are also possible.

Burgers vector (b). A vector that denotes the magnitude and direction of lattice distortion associated with a dislocation.

C

Calcination. A high-temperature reaction whereby one solid material dissociates to form a gas and another solid. It is one step in the production of cement.

Capacitance (C). The charge-storing ability of a capacitor, defined as the magnitude of charge stored on either plate divided by the applied voltage.

Carbon-carbon composite. A composite that is composed of continuous fibers of carbon that are imbedded in a carbon matrix. The matrix was originally a polymer resin that was subsequently pyrolyzed to form carbon.

Carburizing. The process by which the surface carbon concentration of a ferrous alloy is increased by diffusion from the surrounding environment.

Case hardening. Hardening of the outer surface (or "case") of a steel component by a carburizing or nitriding process; used to improve wear and fatigue resistance.

Cast iron. Generically, a ferrous alloy, the carbon content of which is greater than the maximum solubility in austenite at the eutectic temperature. Most commercial cast irons contain between 3.0 and 4.5 wt% C, and between 1 and 3 wt% Si.

Cathode. The electrode in an electrochemical cell or galvanic couple at which a reduction reaction occurs; thus the electrode that receives electrons from an external circuit.

Cathodic protection. A means of corrosion prevention whereby electrons are supplied to the structure to be protected from an external source such as another more reactive metal or a dc power supply.

Cation. A positively charged metallic ion.

Cement. A substance (often a ceramic) that by chemical reaction binds particulate aggregates into a cohesive structure. With hydraulic cements the chemical reaction is one of hydration, involving water.

Cementite. Iron carbide (Fe_3C).

Ceramic. A compound of metallic and nonmetallic elements, for which the interatomic bonding is predominantly ionic.

Ceramic-matrix composite (*CMC*). A composite for which both matrix and dispersed phases are ceramic materials. The dispersed phase is normally added to improve fracture toughness.

Cermet. A composite material consisting of a combination of ceramic and metallic materials. The most common cermets are the cemented carbides, composed of an extremely hard ceramic (e.g., WC, TiC), bonded together by a ductile metal such as cobalt or nickel.

Chain-folded model. For crystalline polymers, a model that describes the structure of platelet crystallites. Molecular alignment is accomplished by chain folding that occurs at the crystallite faces.

Charpy test. One of two tests (see also **Izod test**) that may be used to measure the impact energy or notch toughness of a standard notched

U

Ultimate (tensile) strength. See **Tensile strength.**

Ultrahigh molecular weight polyethylene (*UHMWPE*). A polyethylene polymer that has an extremely high molecular weight (approximately 4×10^6 g/mol). Distinctive characteristics of this material include high impact and abrasion resistance, and a low coefficient of friction.

Unit cell. The basic structural unit of a crystal structure. It is generally defined in terms of atom (or ion) positions within a parallelepiped volume.

Unsaturated. A term describing carbon atoms that participate in double or triple covalent bonds and, therefore, do not bond to a maximum of four other atoms.

Upper critical temperature. For a steel alloy, the minimum temperature above which, under equilibrium conditions, only austenite is present.

V

Vacancy. A normally occupied lattice site from which an atom or ion is missing.

Vacancy diffusion. The diffusion mechanism wherein net atomic migration is from lattice site to an adjacent vacancy.

Valence band. For solid materials, the electron energy band that contains the valence electrons.

Valence electrons. The electrons in the outermost occupied electron shell, which participate in interatomic bonding.

van der Waals bond. A secondary interatomic bond between adjacent molecular dipoles, which may be permanent or induced.

Viscoelasticity. A type of deformation exhibiting the mechanical characteristics of viscous flow and elastic deformation.

Viscosity (η). The ratio of the magnitude of an applied shear stress to the velocity gradient that it produces; that is, a measure of a noncrystalline material's resistance to permanent deformation.

Vitrification. During firing of a ceramic body, the formation of a liquid phase that upon cooling becomes a glass-bonding matrix.

Vulcanization. Nonreversible chemical reaction involving sulfur or other suitable agent wherein crosslinks are formed between molecular chains in rubber materials. The rubber's modulus of elasticity and strength are enhanced.

W

Wave-mechanical model. Atomic model in which electrons are treated as being wavelike.

Weight percent (wt%). Concentration specification on the basis of weight (or mass) of a particular element relative to the total alloy weight (or mass).

Weld decay. Intergranular corrosion that occurs in some welded stainless steels at regions adjacent to the weld.

Welding. A technique for joining metals in which actual melting of the pieces to be joined occurs in the vicinity of the bond. A filler metal may be used to facilitate the process.

Whisker. A very thin, single crystal of high perfection that has an extremely large length-to-diameter ratio. Whiskers are used as the reinforcing phase in some composites.

White cast iron. A low-silicon and very brittle cast iron, in which the carbon is in combined form as cementite; a fractured surface appears white.

Whiteware. A clay-based ceramic product that becomes white after high-temperature firing; whitewares include porcelain, china, and plumbing sanitary ware.

Working point (glass). The temperature at which a glass is easily deformed, which corresponds to a viscosity of 10^3 Pa-s (10^4 P).

Wrought alloy. A metal alloy that is relatively ductile and amenable to hot working or cold working during fabrication.

Y

Yielding. The onset of plastic deformation.

Yield strength (σ_y). The stress required to produce a very slight yet specified amount of plastic strain; a strain offset of 0.002 is commonly used.

Young's modulus. See **Modulus of elasticity.**

An
Sel

Chapte
2.3 (a)
(b)
2.13
2.14 (c)
2.19 63.
Chapte
3.3 V_C
3.9 R
3.12 (a)
(b)
3.15 M
3.17 (a)
3.20 V_C
3.27 (a)
3.29 Di
3.30 Di
3.31 (b
3.33 Pl
3.34 Pl
3.35 Pl
3.37 (a
3.40 (a
3.41 (c
3.42 [1
3.43 [1